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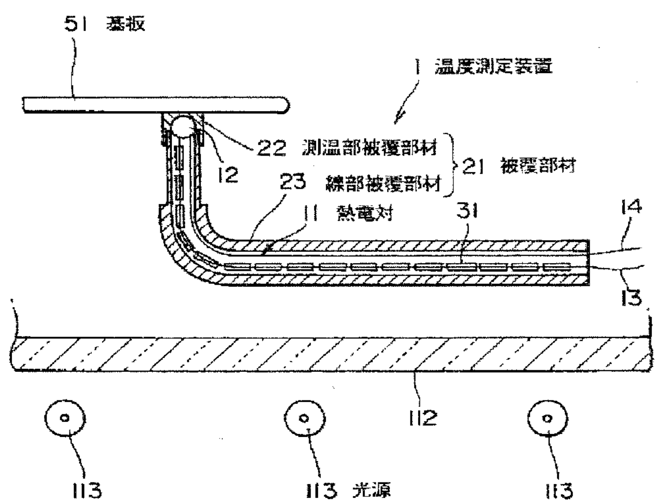
# (54)【発明の名称】　半導体装置製造の熱処理工程における温度制御方法

(57)【要約】

【課題】　光照射強度により基板毎の輻射率が異なると基板温度の正確な測定が難しくなるため、光照射強度を変える閉回路制御の実施は困難であった。

【解決手段】　光源１１３からの光照射により加熱される基板５１の温度を熱電対１１により接触式に計測するもので、加熱手段に光源１１３を有する加熱炉内に収容される温度測定装置１を用いた温度制御方法であって、その温度測定装置１は、その熱電対１２の被覆部材２１における、基板５１との接触部周辺（測温部被覆部材２２）は熱伝導率の高い材料で形成され、その接触部周辺を除く被覆部材２１（線部被覆部材２３）は光透過率の高い材料または光反射率の高い材料で形成されたものであり、その温度測定装置１を用いて基板５１の温度を測定する工程と、その測定した値を光源１１３の出力にフィードバックする閉回路制御を行う工程とを備えた温度制御方法である。



【特許請求の範囲】

【請求項１】　加熱手段に光源を有する加熱炉内に収容され、前記光源からの光照射により加熱される基板の温度を熱電対により接触式に測定する温度測定装置を用いた半導体装置製造の熱処理工程における温度制御方法であって、

前記温度測定装置の熱電対を被覆する被覆部材における、前記基板との接触部周辺は熱伝導率の高い材料で形成され、かつ前記基板との接触部周辺を除く前記被覆部材は光透過率の高い材料または光の反射率の高い材料で形成された該温度測定装置を用いて、前記基板の温度を測定する工程と、

前記測定した値を前記光源の出力にフィードバックして、前記基板の温度を所定範囲内に保持するように該光源の出力を調節する閉回路制御を行う工程とを備えたことを特徴とする半導体装置製造の熱処理工程における温度制御方法。

【請求項２】　請求項１記載の半導体装置製造の熱処理工程における温度制御方法において、

前記基板との接触部周辺の被覆部材が炭化シリコン、シリコン化合物もしくはアルミナからなる前記温度測定装置を用いて前記基板の温度を測定することを特徴とする半導体装置製造の熱処理工程における温度制御方法。

【請求項３】　請求項１記載の半導体装置製造の熱処理工程における温度制御方法において、

前記温度測定装置は、所定回数の熱処理を行った後、前記基板の温度測定に用いることを特徴とする半導体装置製造の熱処理工程における温度制御方法。

【請求項４】　請求項１記載の半導体装置製造の熱処理工程における温度制御方法において、

前記温度測定装置は、所定回数の熱処理を行った後、前記基板の温度測定に用いることを特徴とする半導体装置製造の熱処理工程における温度制御方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、半導体装置製造の熱処理工程における温度制御方法に関し、詳しくは閉回路制御による温度制御方法に関する。

【０００２】

【従来の技術】近年、半導体デバイスの微細化にともないＭＯＳデバイスでは、①短チャネル効果を抑制するため、②バイポーラデバイスでは遮断周波数 $f_T$ を向上させるために、浅い接合を高精度に形成する必要性が生じている。そして浅い接合を形成する方法の一つとして、高温で短時間の処理が可能な光照射による加熱方法（ＲＴＡ：Rapid Thermal Annealing ）が採用されている。またＲＴＡは、イオン注入により生じた結晶欠陥の回復やシンター等の各種アニーリング、酸化膜、窒化膜の形成にも利用されている。そのため、さまざまな膜構造を有する基板、さまざまな不純物濃度を有する基板等に対し、基板温度を正確に制御することが極めて重要になっている。

【０００３】しかし、光照射による基板加熱では、膜構造や膜質、不純物濃度等により基板の輻射率が変化するため、光の照射強度が一定〔開回路制御（Open Loop Control ）〕のもとでは、基板の光吸収量（処理温度）が変化することになる。そのため、製造工程の複雑化にともない、各種ばらつき（膜厚、膜質、不純物量、構造等によるばらつき）を含む基板の加熱状態を精度よく制御することは極めて難しい。さらに基板加熱装置を構成する石英チューブの光透過率やチャンバの内壁の光反射率、光源となるランプの出力の経時的な変化等によって基板の処理温度が変化する。この問題に対処するため、基板の温度を測定してその測定値をランプの出力にフィードバックする閉回路制御（Closed Loop Control ）が検討されている。これにより、精度の高い基板温度の測定が実現できれば、優れた基板温度制御が可能になる。

【０００４】また、基板の温度を測定する装置としては放射温度計がある。この放射温度計は非接触で温度測定ができる利点がある。別の温度測定装置としては熱電対がある。熱電対で温度測定する場合には、基板の表面に熱電対を直接接触させる方法、耐熱性接着剤を用いて基板の表面に熱電対を固定する方法等がある。これらの方法は、熱電対の測温部（合金部）が基板に直接接触するので、基板温度をほぼ正確に測定することができるという長所を有する。

【０００５】他の温度測定装置としては、シリコンカーバイド（ＳｉＣ）からなる被覆部材に熱電対を内挿し、その熱電対を被覆部材を介して基板に接触させて、基板温度を間接的に測定する装置が特開平４－１４８５４６号公報に開示されている。

【０００６】

【発明が解決しようとする課題】しかしながら、上記放射温度計を用いた温度測定では、熱電対を用いた接触式の温度測定方法と異なり、測定対象の表面状態によって測定精度が左右されたり、測定環境の影響を強く受ける。そのため、様々な膜構造や不純物濃度を持つ基板では基板毎に輻射率が異なり、正確な温度測定を行うことが困難である。

【０００７】また、基板に熱電対を直接接触させて温度測定する方法では、基板と熱電対との反応による熱電対の劣化、基板の金属汚染等の問題が発生する。

【０００８】さらに被覆部材に内装した熱電対による温度測定では、熱電対による基板への金属汚染の問題は解決されるが、熱電対が測定しているのは被覆部材の温度になる。また光照射型熱処理装置により基板が熱処理される過程で、基板の温度が上昇すると、熱伝導により被覆部材が加熱されるだけではなく、被覆部材自体が照射された光を直接吸収して加熱される。よって、光照射強度を変える閉回路制御は、照射強度に依存して被覆部材

の光吸収による加熱量が変化するため、様々な膜構造や不純物濃度を持つ基板の輻射率の変化による光吸収量（基板温度）の変化を正確に測定することは難しい。このように、基板温度の精度の高い測定技術がないことから、従来の閉回路制御による基板温度制御には問題があった。

【０００９】また基板からの熱伝導と被覆部材からの輻射吸収、および照射ランプ光の吸収は、被覆部材として用いる材料により異なる。石英と炭化シリコン（ＳｉＣ）の場合を例に示すと、石英による被覆では、光吸収が抑えられるが、熱伝導が悪いために基板温度の測定が難しく熱応答性も劣る。一方、炭化シリコンによる被覆では、基板温度の伝導には優れるが、光吸収が多いために測定温度の光照射強度依存が顕著に現れる。このような熱特性により、それぞれの材料には一長一短がある。

【００１０】また、被覆部材と基板との接触部において被覆部材を平坦に加工して、疑似的な面接触状態を形成し、基板からの熱伝導効率を増す方法もあるが、この方法では被覆部材の熱容量を増やすことにもなる。そのため、光の直接吸収による加熱が増えるので正確な基板の温度測定ができない。

【００１１】よって、光照射強度を変える閉回路制御では、照射強度に依存して被覆部材の光吸収による加熱量が変化するため、さまざまな膜構造や不純物濃度を持った基板の輻射率の変化による光吸収量（基板温度）の変化を正確に測定することはできない。

【００１２】

【課題を解決するための手段】本発明は、上記課題を解決するためになされた半導体装置製造の熱処理工程における温度制御方法であり、加熱手段に光源を有する加熱炉内に収容され、その光源からの光照射によって加熱される基板の温度を熱電対により接触式に測定する温度測定装置を用いた温度制御方法である。上記温度測定装置の熱電対を被覆する被覆部材における、基板との接触部周辺は熱伝導率の高い材料で形成され、かつ基板との接触部周辺を除く被覆部材は光透過率の高い材料または光の反射率の高い材料で形成されている、このような温度測定装置を用いて、基板の温度を測定する工程と、その測定した値を前記光源の出力にフィードバックする閉回路制御を行う工程とを備えている。

【００１３】上記半導体装置製造の熱処理工程における温度制御方法では、上記構成の温度測定装置による基板温度の測定と、その測定値を光源の出力にフィードバックする閉回路制御とを組み合わせることにより、基板温度の制御精度が高まる。すなわち、上記温度測定装置では、熱電対が被覆部材により被覆され、この被覆部材のうち、測温部を覆う部分の被覆部材が熱伝導性の高い材料からなることから、基板の熱が測温部に伝導し易くなる。そのため、被覆部材を介しての温度測定ではあるが、基板の温度を精度良く測定することが可能になる。

【００１４】また、この熱伝導性の高い材料からなる被覆部材を除く他の部分の被覆部材は光の透過率の高い材料または光の反射率の高い材料からなることから、その部分の被覆部材が光の照射を受けてその光を吸収することがほとんどない。そのため、光の照射による被覆部材の温度上昇がほとんどなくなるので、被覆部材の吸熱による熱電対の測温値の変化、基板からの輻射による測温値の変化がほとんど起こらない。したがって、基板温度を高精度に測定することが可能になり、その温度に基づいて光源の出力に対してフィードバックをかけることから、基板温度を高精度に制御することが可能になる。

【００１５】

【発明の実施の形態】本発明に係わる半導体装置製造の熱処理工程における温度制御方法の実施形態の一例を、図１に温度測定装置を基板とともに概略断面図によって説明し、光照射型熱処理装置の一例を図２の概略構成断面図によって説明する。

【００１６】図１に示すように、半導体装置製造の熱処理工程において被熱処理基板の温度測定に用いる温度測定装置１は、図２によって説明する加熱手段に光源１１３を有する加熱炉（石英製のチューブ１１２）内に収容され、上記光源１１３からの光照射により加熱される基板５１の温度を熱電対１１により接触式に測定するものである。その熱電対１１を被覆する被覆部材２１における上記基板５１との接触部周辺（測温部１２の測温部被覆部材２２）は熱伝導率の高い材料からなる。そのような材料としては、例えば炭化シリコン、シリコン化合物（例えば、モリブデンシリサイド、チタンシリサイド、コバルトシリサイド等のシリサイド）もしくはアルミナが用いられている。一方、上記基板５１との接触部周辺を除く上記温度測定装置１の被覆部材２１（線部被覆部材２３）は光透過率の高い材料または光の反射率が高い材料からなる。光透過率の高い材料としては、例えば石英が用いられている。または光の反射率が高い材料としては、例えばアルミナが用いられている。

【００１７】具体的には、接触式熱電対からなる温度測定装置１は、熱電対１１が被覆部材２１によって被覆されている構造となっている。この熱電対１１は、例えば、白金（Ｐｔ）－白金（Ｐｔ）・１０％ロジウム（Ｒｈ）熱電対であり、熱電対１１の測温部（合金部）１２は、白金線と白金・１０％ロジウム線との合金により形成されている。また少なくともいずれか一方の線は絶縁管３１内に遊挿されていて、この絶縁管３１は例えば石英からなる。この例では、白金の導線１３の方が絶縁管３１内に遊挿されている。当然のことながら、白金・１０％ロジウム線１４の方が絶縁管３１内に遊挿されていてもよい。

【００１８】上記被覆部材２１のうち、上記測温部１２を覆う部分の測温部被覆部材２２は、熱伝導性の高い材料で構成され、測温部１２に十分に接触する状態に設け

られている。この測温部被覆部材２２は、例えば石英（熱伝導率＝１．６６W・$m^{-1}$・$K^{-1}$）の十倍程度以上の熱伝導率を有する材料、好ましくは１００W・$m^{-1}$・$K^{-1}$程度以上の熱伝導率を有する材料からなる。このような材料としては、例えば炭化シリコン（熱伝導率＝２６１W・$m^{-1}$・$K^{-1}$）がある。

【００１９】上記測温部被覆部材２２は、測温部１２に十分に接触し、かつ、熱伝導性の高い材料である炭化シリコンで形成されている。このことから、測温部被覆部材２２を介しての温度測定ではあるが、基板５１の熱は測温部１２へ十分に伝わり、基板５１の温度を測定することが可能になる。さらに測温部被覆部材２２は、光の直接の吸収を極力抑えるために表面積を小さく、また熱応答性を高めるために熱容量の小さな構造としている。すなわち、測温部被覆部材２２の形状は、測温部１２に対してキャップ形状を成していて、例えば、キャップの外径が１．４mm、キャップの内径が０．９mm、キャップの高さ１．４mmに形成されている。

【００２０】また、上記被覆部材２１のうち、上記測温部被覆部材２２を除く他の部分の線部被覆部材２３は、赤外線の透過性に優れた石英で構成されていて、しかも光の直接の吸収を極力抑えた構造として円形断面を有する管状に形成されているので、光の照射を受けてもその光を吸収することがほとんどない。よって、光の照射による線部被覆部材２３の温度上昇がほとんどなくなるので、線部被覆部材２３の吸熱による熱電対１１の測温値の変化はほとんど起こらない。

【００２１】また、一般に熱電対１１の導線１３，１４の各表面は光を反射し易い状態に形成されている。そのため、熱電対１１に光が照射されても、熱電対１１は照射された光の影響をほとんど受けることはない。さらに、上記測温部被覆部材２２が耐熱性が高く通常のシリコン基板の熱処理温度（１２００℃以下）では熱的に安定な炭化シリコンで形成されているため、熱処理時に上記測温部被覆部材２２によって基板５１が汚染されることもない。

【００２２】なお、基板５１は、石英トレー（図示省略）より突出した石英製の複数本（例えば２本）の基板支持部（図示省略）とともに、上記温度測定装置１の先端部分になる測温部被覆部材２２によって水平に支持されている。

【００２３】次に、上記実施形態で説明した温度測定装置１を使用する光照射型熱処理装置の一例を、図２の概略構成断面図によって説明する。

【００２４】図２に示すように、金で被覆された反応炉１１１の内部には、赤外線に対して高い透過性を有する石英ガラスによりなるチューブ１１２が設置され、このチューブ１１２の側周に加熱用の光源１１３となるハロゲンランプが設置されている。そして反応炉１１１の一端側に上記チューブ１１２の一端側を設け、その部分には、基板５１の搬出入の際に開閉し、さらに上記チューブ１１２内を密閉する時にはこのチューブ１１２内を気密にできるように、パッキン１１４（例えば樹脂製のパッキン）を装着したドア１１５が備えられている。

【００２５】一方、上記チューブ１１２の他端側にはガスを導入するためのガス導入管１１６が接続されている。そして上記チューブ１１２の内部には、基板５１を支持するための石英製のトレー１１７が置かれている。このトレー１１７には石英製の基板支持部１１８が形成されていて、この基板支持部１１８とともにトレー１１７上に配置した温度測定装置１の先端部（前記図１によって説明した測温部被覆部材２２を介した測温部１２）によって基板５１が支持されている。また温度測定装置１の熱電対の導線１３，１４は反応炉１１１の端部に設けた孔１１９より外部に引き出されている。また反応炉１１１にはパイロメーター１３１により温度測定を可能とする窓１２０が形成されている。このように、光照射型熱処理装置１０１は構成されている。

【００２６】上記図１によって説明した温度測定装置１を用いて、第１工程では、図２によって説明した光照射型熱処理装置１０１により加熱される上記基板５１の温度を測定する。

【００２７】次いで第２工程で、上記基板５１の温度の測定値を上記光源１１３の出力にフィードバックして、基板５１の温度を所定範囲内に保持するように光源１１３の出力を調節する閉回路制御を行う。

【００２８】上記閉回路制御は、例えば、基板温度が高い場合にはその測定温度値と設定温度値との差を求め、その差に基づいて光源１１３の出力を減少させて基板温度を設定温度に一致させるようにし、一方、基板温度が低い場合にはその測定温度値と設定温度値との差を求め、その差に基づいて光源１１３の出力を増加させることにより基板温度を設定温度に一致させるようにして、常に基板温度が設定温度に保持されるようにする。上記基板温度の測定値と設定温度値との差より光源の出力の増減量は、例えば予め求めておいたデータに基づいて決定すればよい。

【００２９】上記半導体装置製造の熱処理工程における温度制御方法では、上記構成の温度測定装置１による基板５１の温度測定と、その測定値を光源１１３の出力にフィードバックする閉回路制御とを組み合わせることにより、基板５１の温度制御の精度が高まる。すなわち、上記温度測定装置１では、熱電対１１が被覆部材２１により被覆され、この被覆部材２１のうち、測温部１２を覆う部分の測温部被覆部材２２が熱伝導性の高い材料からなることから、基板５１の温度が測温部１２に伝導し易くなる。そのため、測温部被覆部材２２を介しての温度測定ではあるが、基板５１の温度を精度良く測定することが可能になる。

【００３０】また、測温部被覆部材２２を除く他の部分

の線部被覆部材２３は光の透過率の高い材料または光の反射率の高い材料からなることから、その線部被覆部材２３が光の照射を受けてその光を吸収することがほとんどない。そのため、光の照射による線部被覆部材２３の温度上昇がほとんどなくなるので、線部被覆部材２３の吸熱による熱電対１１の測温値の変化、基板５１からの輻射による測温値の変化がほとんど起こらない。したがって、基板５１の温度を高精度に測定することが可能になり、その温度に基づいて光源１１３の出力に対してフィードバックをかけることから、基板５１の温度を高精度に制御することが可能になる。

【００３１】次に比較例として従来の接触式熱電対の温度測定装置を、図３の概略構成断面図によって説明する。図３では、従来型の温度測定装置２０１が光照射型熱処理装置の石英製のチューブ１１２内に挿入されていて、基板５１の温度を測定している状態を示しており、前記図１によって説明した構成部品と同様のものには同一符号を付与する。この従来型の温度測定装置２０１は、熱電対１１が炭化シリコン（ＳｉＣ）からなる被覆部材２２１によって被覆されている構造となっている。この熱電対１１は、例えば、白金（Ｐｔ）－白金（Ｐｔ）・１０％ロジウム（Ｒｈ）熱電対であり、熱電対１１の測温部（合金部）１２は、白金線と白金・１０％ロジウム線との合金により形成されている。また少なくともいずれか一方の線は絶縁管３１内に遊挿されていて、この絶縁管３１は例えば石英からなる。この例では、白金の導線１３の方が絶縁管３１内に遊挿されている。

【００３２】上記従来型の温度測定装置２０１では、熱電対１１が測定しているのは被覆部材２２１の温度である。光照射型熱処理装置（図示省略）により基板５１が熱処理される過程で、基板５１が加熱されてその温度が上昇すると、基板５１からの熱伝導により被覆部材２２１が加熱されるだけではなく、被覆部材２２１自身が光源１１３の光を直接吸収して加熱されるため、基板温度の正確な測定は困難となる。基板５１からの熱伝導と被覆部材２２１の基板５１からの輻射、および光源１１３からの光の吸収は、被覆部材２２１として用いる材料により異なり、石英と炭化シリコンの場合を例に示すと、石英は、輻射吸収が少なく熱伝導が悪いために、基板温度の測定が難しく熱応答性も劣る。一方、炭化シリコンは輻射吸収が多く熱伝導が良いために、炭化シリコンによる被覆では基板温度の伝導には優れるが光吸収が多く測定温度の光照射強度依存が顕著に現れる。

【００３３】次に基板の輻射率を変えるための膜厚を変化させた３種類のサンプルの構造を図４によって説明する。

【００３４】図４の（１）に示すように、第１評価サンプル６１は、シリコン基板６２の一方側（表面側）に酸化シリコン（$SiO_2$）膜６３、１５０ｎｍの厚さの多結晶シリコン膜６４、３００ｎｍの厚さのキャッピング酸化シリコン膜６５が積層され、シリコン基板６２の他方側（裏面側）に酸化シリコン（$SiO_2$）膜６６、１５０ｎｍの厚さの多結晶シリコン膜６７が積層されたものである。そして上記酸化シリコン膜６３，６６は７００ｎｍ～９００ｎｍの範囲で厚さを変えているが、光吸収量の膜厚依存性は少ないものとなっている。また多結晶シリコン膜６４には打ち込みエネルギーが４０ｋｅＶ、ドーズ量が$5.4\times10^{14}$個／$cm^2$なる条件で二フッ化ホウ素（$BF_2$）がイオン注入されている。

【００３５】図４の（２）に示すように、第２評価サンプル７１は、シリコン基板７２の一方側（表面側）に８００ｎｍの厚さの酸化シリコン（$SiO_2$）膜７３、１５０ｎｍの厚さの多結晶シリコン膜７４、３００ｎｍの厚さのキャッピング酸化シリコン膜７５が積層され、シリコン基板７２の他方側（裏面側）に８００ｎｍの厚さの酸化シリコン（$SiO_2$）膜７６、多結晶シリコン膜７７が積層されたものである。そして上記裏面側の多結晶シリコン膜７７は１５０ｎｍ～３５０ｎｍの範囲で厚さを変化させており、光吸収量の膜厚依存性は第１評価サンプル６１よりも大きくなっている。また表面側の多結晶シリコン膜７４には、打ち込みエネルギーが４０ｋｅＶ、ドーズ量が$5.4\times10^{14}$個／$cm^2$なる条件で二フッ化ホウ素（$BF_2$）がイオン注入されている。

【００３６】図４の（３）に示すように、第３評価サンプル８１は、シリコン基板８２の一方側（表面側）に酸化シリコン（$SiO_2$）膜８３、１５０ｎｍの厚さの多結晶シリコン膜８４、３００ｎｍの厚さのキャッピング酸化シリコン膜８５が積層され、シリコン基板８２の他方側（裏面側）に酸化シリコン（$SiO_2$）膜８６、１５０ｎｍの厚さの多結晶シリコン膜８７が積層されたものである。そして上記第３評価サンプル８１は、酸化シリコン膜８３，８６の厚さが１００ｎｍ～６００ｎｍの範囲、すなわち、１００ｎｍ、２００ｎｍ、３００ｎｍ、４００ｎｍ、６００ｎｍの５種類のものが用意されている。そのため、これらの第３評価サンプル８１においては酸化シリコン膜８３，８６の光吸収の膜厚依存性は極めて大きいものとなっている。また多結晶シリコン膜８４には、打ち込みエネルギーが４０ｋｅＶ、ドーズ量が$5.4\times10^{14}$個／$cm^2$なる条件で二フッ化ホウ素（$BF_2$）がイオン注入されている。

【００３７】酸化シリコン膜６３の膜厚が異なる複数の各第１評価サンプル６１，多結晶シリコン膜７７の膜厚が異なる複数の各第２評価サンプル７１，酸化シリコン膜８３，８６の膜厚が異なる複数の各第３評価サンプル８１のそれぞれに、耐熱性接着剤を用いて熱電対を直接張りつけて、その熱電対を用いた正確な温度測定を行った。

【００３８】温度測定では、前記図２によって説明した光照射型熱処理装置１０１を用いて基板５１の代わりに上記図４によって説明した各第１，第２，第３評価サン

プル６１，７１，８１を熱処理〔ＲＴＡ（Rapid Thermal Annealing ）〕した。そのＲＴＡのシーケンスは、図５に示すように、２００℃の温度雰囲気に設定したチューブ１１２（図２参照）内に評価サンプルを搬入する。そして５０℃／ｓの加熱速度でＲＴＡの設定温度Ｔまで加熱した後、その設定温度Ｔにｔ秒間（例えば１０秒間）保持し、その後５０℃／ｓの冷却速度で４００℃まで冷却して、チューブ１１２内から評価サンプルを搬出するという順である。上記ＲＴＡの設定温度Ｔは、９００℃、１０００℃、１０５０℃、１１００℃、１１５０℃に設定した。なお、上記ＲＴＡのシーケンスは一例であり、適宜変更することは可能である。

【００３９】ここで、各設定温度で処理をしたときの各評価サンプルのシート抵抗の温度依存性を図６に示す。図６では、縦軸にシート抵抗$\rho$ｓを示し、横軸にＲＴＡの設定温度を示す。図６に示すように、９００℃から９５０℃程度まではほぼ一定の２１４０Ω／□程度のシート抵抗値を示し、１０００℃程度より高温になると急激にシート抵抗が低下する。そして１０５０℃では１４２０Ω／□程度のシート抵抗値になり、１１００℃では９８０Ω／□程度のシート抵抗値を示し、１１５０℃では８００Ω／□程度のシート抵抗値になった。

【００４０】図７は、本発明の温度測定器１（図１参照）および従来型の温度測定装置２０１（図３参照）によって測定した各評価サンプルのシート抵抗$\rho$ｓ（縦軸）と測定温度（横軸）との関係を示したものである。温度測定器１による測定値は白抜きの丸、三角、四角印で示し、温度測定装置２０１による測定値は黒塗りの丸、三角、四角印で示す。

【００４１】具体的には、第２評価サンプル７１における多結晶シリコン膜７７の膜厚が２５０ｎｍの評価サンプルにおいて基板温度は１０５０℃になるようなランプ出力を用い、第１評価サンプル６１の酸化シリコン膜６３，６６の厚さ、第２評価サンプル７１の多結晶シリコン膜７７の厚さ、および第３評価サンプル８１の酸化シリコン膜８３，８６の厚さを変えた全ての評価サンプルに対して、同一ランプ出力で熱処理を行う。すなわち、光の照射強度が一定のもとで熱処理を行うという開回路制御により連続処理を行い、シート抵抗および基板温度を測定する。

【００４２】図７に示すように、基板によらず同じ光照射強度で処理する開回路制御では、基板表面に形成された膜の厚さの違いによりシート抵抗（基板温度）が変化する。また、図６および図７において、ＲＴＡの設定温度によるシート抵抗の温度依存の曲線と、温度測定装置１による測定温度でのシート抵抗の温度依存の曲線とを比較すると、曲線の形は一致している。このことから、基板構造が異なり光の吸収量が違うさまざまな基板に対しても、温度測定装置１（図１参照）は基板温度の正確な測定を再現性良くできることを示している。これに対し、従来型の温度測定装置２０１（図３参照）により測定した測定温度とそのときのシート抵抗との関係は、図６の温度依存の曲線と大幅に異なることがわかり、従来型の温度測定装置２０１は基板温度の正確な測定ができていないことを示している。

【００４３】第３評価サンプル８１の酸化シリコン膜８３，８６の膜厚を変化させたサンプルを、温度測定装置２０１（図３参照）と温度測定装置１（図１参照）とを用いた閉回路制御にて、前記図５によって説明したシーケンスにより測定温度１０５０℃で処理を施し、この時のシート抵抗の膜厚依存性を開回路制御における膜厚依存性とともに図８に示す。この図８では、縦軸にシート抵抗$\rho$ｓを示し、横軸に酸化シリコン膜厚を示し、図中の黒塗りの丸印は開回路制御、白抜きの四角印は温度測定装置１による閉回路制御、白抜きの三角印は従来型の温度測定装置２０１による閉回路制御を示す。また、同様に、シート抵抗からの換算温度の膜厚依存性を図９に示し、図中の黒塗りの丸印は開回路制御、白抜きの四角印は温度測定装置１による閉回路制御、白抜きの三角印は従来型の温度測定装置２０１による閉回路制御を示す。この図９では、縦軸に基板温度を示し、横軸に酸化シリコン膜厚を示す。図８および図９から明らかなように、開回路制御において顕著に現れるシート抵抗（基板温度）の膜厚依存は、温度測定装置１を用いることで改善される。しかし、温度測定装置２０１では、シート抵抗（基板温度）の膜厚依存の改善効果がみられない。

【００４４】温度測定装置１（図１参照）と温度測定装置２０１（図３参照）とを用いた閉回路制御により第３評価サンプル８１の酸化シリコン膜８３，８６の膜厚を変化させたサンプルを前記図５によって説明したシーケンスにより測定温度１０５０℃で処理を施した時の、酸化シリコン膜８３，８６の膜厚による安定時のランプ出力を図１０に示した。この図１０では、縦軸にランプ出力（最大出力に対する出力比）を示し、横軸に酸化シリコン膜厚を示し、図中の黒塗りの丸印は開回路制御、白抜きの四角印は温度測定装置１による閉回路制御、白抜きの三角印は従来型の温度測定装置２０１による閉回路制御を示す。

【００４５】図１０に示すように、温度測定装置１を用いた閉回路制御では、基板温度が低くなる酸化シリコン膜厚においてより高いランプ出力を加えて基板温度を補正しているのがわかる。しかし、前記図７に示すように、温度測定装置２０１では、実際に基板温度が変わっていても、測定温度がほとんど変わらないため、酸化シリコン膜厚に依らずほぼ同じランプ出力となり、酸化シリコン膜厚により基板温度を補正することができていない。以上のことから、温度測定装置２０１では、ランプからの光を温度測定装置２０１が直接吸収していることを証明している。このように、温度測定装置の構造としては、炭化シリコンの表面積を減らして、光吸収を極力

抑えた構造にする必要があることがわかる。要するに、従来温度測定装置２０１のように熱電対１１を全て覆った構造では、光吸収が多く、閉回路制御における精度の良い測定はできない。

【００４６】上記図６～図１０では、酸化シリコン膜厚により極端に基板の光吸収量が変わる第３評価サンプル８１の結果を用いて、温度測定装置１による閉回路制御の結果を示したが、実際の管理された半導体装置の製造工程においては、膜厚や膜質の工程ばらつきによる光吸収（基板温度）の変動は、はるかに少なく、温度測定装置１を用いた閉回路制御により、開回路制御におけるシート抵抗（基板温度）の膜厚依存を十分に解消できる。

【００４７】以上のように、閉回路制御において精度の良い測定を行うためには、測温部に被覆する炭化シリコンの構造を極力小さくし、光吸収を抑える必要がある。

【００４８】一例として、膜厚を変化させ、光の吸収量を変えた基板を用いて、閉回路制御の効果を示したが、温度測定装置１（図１参照）を用いた閉回路制御では、実際の基板温度を測定し、光源１１３となるランプの出力にフィードバックするため、光照射型熱処理装置１０１を構成する石英製のチューブ１１２の光透過率や反応炉１１１の内壁の光反射率、光源１１３となるランプの出力の経時的な変化等によっての基板５１の処理温度が変化するような場合にも、本発明により、精度の高い基板温度の測定が実現される。

【００４９】この制御方法の安定性を評価するため、温度測定装置１（図１参照）を用いた閉回路制御により、前記図５によって説明したシーケンスにより測定温度１０５０℃で１０秒間の熱処理を実行し、この時の温度測定装置１とパイロメーターの測定温度、ならびに光源１１３となるランプの出力を読み取ることにより、１３５０枚の連続処理における温度測定装置１による閉回路制御の安定性を評価した。サンプルには、６００ｎｍの熱酸化膜（$SiO_2$ 膜）が形成されたシリコン基板を使用し、測定温度とランプ出力のサンプリングを同じシリコン基板から行うことで、シリコン基板の輻射率ばらつきによるパイロメーターの測定誤差を排除した。

【００５０】図１１に示す温度測定装置１の測定温度の推移は、温度測定装置１による閉回路制御であるため、当然１０５０℃で一定となる。この図１１では、縦軸に測定温度を示し、横軸に基板の処理枚数を示す。

【００５１】しかしながら、実際の基板温度は、温度測定装置１のドリフトのために一定ではなく、このドリフトは、同一サンプルに対して同一条件であれば、ほぼ正確な基板温度を測定するパイロメーターの推移（図１３）により知ることができる。この結果を図１２によって説明する。この図１２では、左縦軸にパイロメーターによる測定温度を示し、右縦軸にドリフト温度を示し、横軸に基板の処理枚数を示す。図１２に示すように、新品の温度測定装置１を使いはじめてから、２００枚程度までは、０℃から－３℃程度へのドリフトがみられるが、２００枚目以降は、例えば－３℃を中心として±１．０℃以下の非常に優れた温度制御が可能であることがわかる。

【００５２】また、図１３に、ランプ出力（縦軸）と基板の処理枚数（横軸）との関係を示す。ここで示すランプ出力は最大ランプ出力に対する比率である。この図１３に示すように、ランプ出力は、およそ５０枚の連続処理を行った後は、±０．５％程度のばらつきの範囲内で安定した出力となることがわかる。

【００５３】以上のことより、新品の温度測定装置１を使用する際には、例えば前記図５によって説明したシーケンスにより測定温度１０５０℃で１０秒間の熱処理を２００回程度施す必要がある。所定回数の連続した熱処理を施した温度測定装置１による閉回路制御によって非常に安定な基板温度制御が実現される。なお、上記熱処理回数の２００回というのは一例であって、その熱処理回数は熱処理条件（温度、時間等）によって適宜選択される。

【００５４】

【発明の効果】以上、説明したように本発明によれば、温度測定装置の測温部の被覆部材が熱伝導性の高い材料からなるので測温部に基板温度が十分に伝わり、他の部分の被覆部材が光透過率または光反射率の高い材料からなるのでこの部分の被覆部材は光をほとんど吸収しない。そのため、本温度測定装置により基板温度を正確に測定することができる。この温度測定装置を、基板温度をランプ出力にフィードバックして基板を所望の温度に制御する閉回路制御に用いるので、膜構造、膜質、不純物濃度等による輻射率や光吸収量（処理温度）が変化する基板を熱処理する場合であっても、基板温度を精度良く制御することが可能になる。さらに光照射型熱処理装置を構成する石英チューブの光透過率、反応炉内壁の光反射率、光源となるランプの出力等の経時的な変化があっても基板温度の安定な制御を実現することができる。

【図面の簡単な説明】

【図１】本発明の温度制御方法に係わる実施形態の説明図である。

【図２】温度測定装置を使用する光照射型熱処理装置の概略構成断面図である。

【図３】比較例の温度測定装置の概略構成断面図である。

【図４】各評価サンプルの概略構成断面図である。

【図５】ＲＴＡのシーケンスの説明図である。

【図６】各評価サンプルのシート抵抗とＲＴＡの設定温度との関係図である。

【図７】本発明の温度測定装置および比較例の温度測定装置による測定温度とシート抵抗との関係図である。

【図８】第３評価サンプルのシート抵抗と酸化シリコン膜厚との関係図である。

【図９】第３評価サンプルの基板温度と酸化シリコン膜厚との関係図である。

【図１０】第３評価サンプルでのランプ出力比と酸化シリコン膜厚との関係図である。

【図１１】ＲＴＡの連続処理における本発明の温度測定装置による測定温度と基板処理枚数との関係図である。

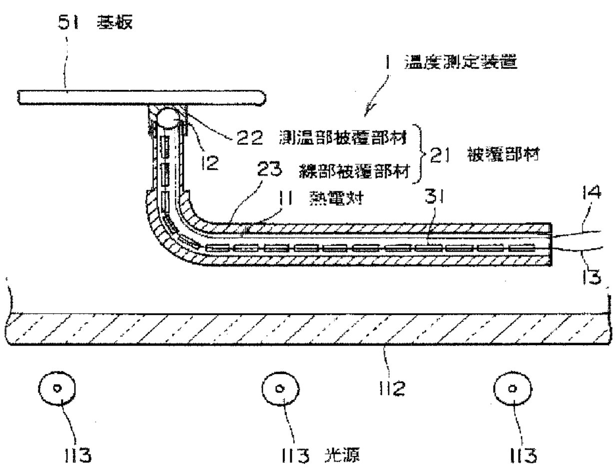
【図１２】ＲＴＡの連続処理におけるパイロメーターによる測定温度と基板処理枚数との関係図および本発明の温度測定装置の測定温度のドリフト量と基板処理枚数との関係図である。

【図１３】ＲＴＡの連続処理におけるランプ出力と基板処理枚数との関係図である。

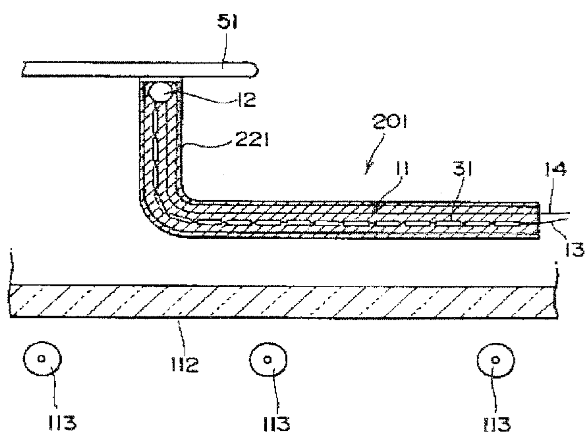
【符号の説明】

１…温度測定装置、１１…熱電対、２１…被覆部材、２２…測温部被覆部材、２３…線部被覆部材、５１…基板、１１３…光源

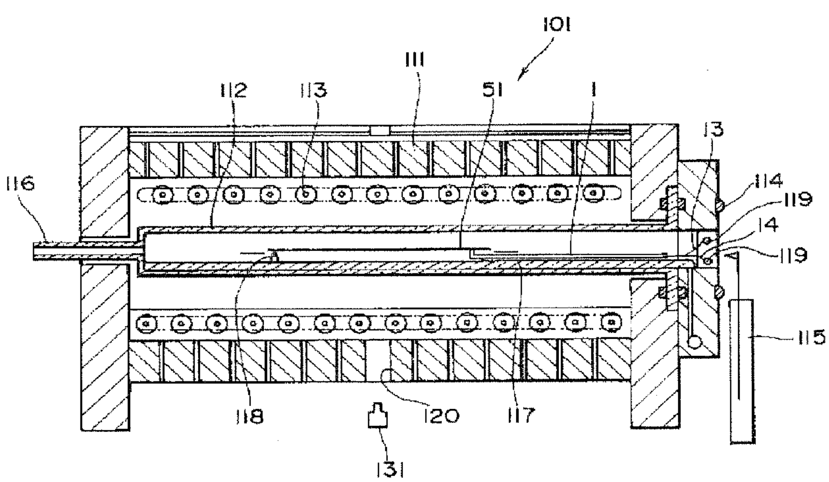
【図１】



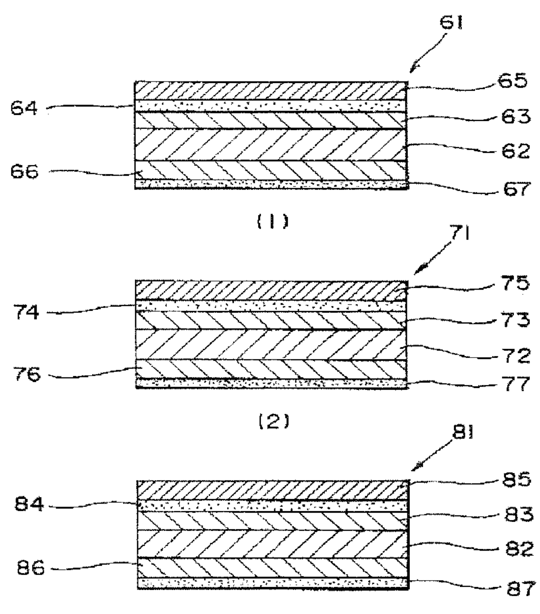

【図３】




【図２】




【図４】



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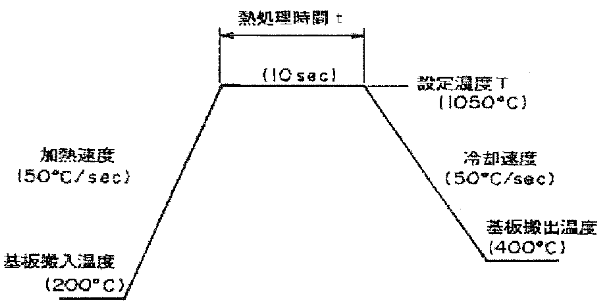
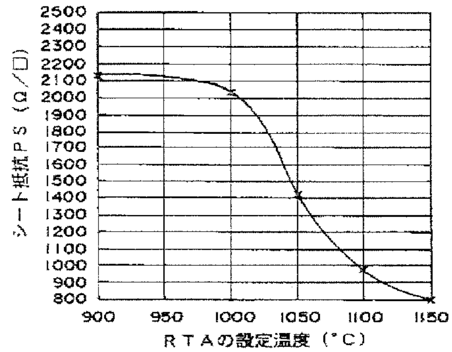
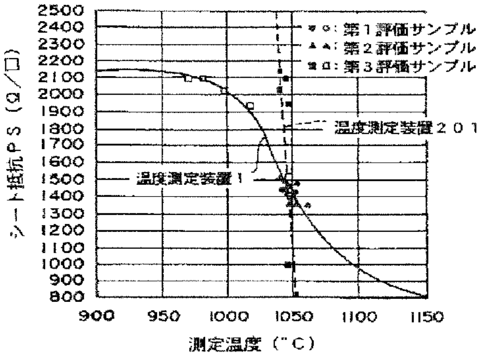


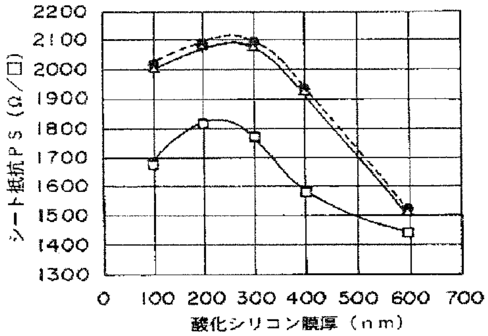

【図６】



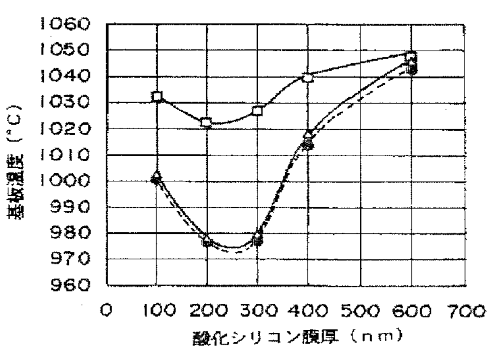

【図７】



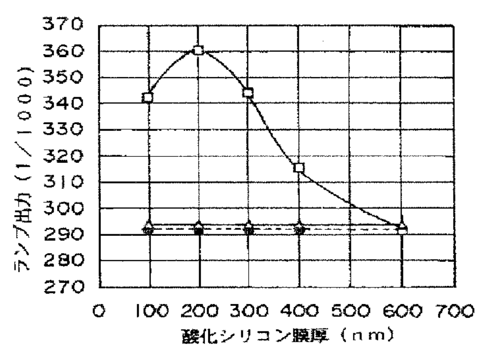

【図８】



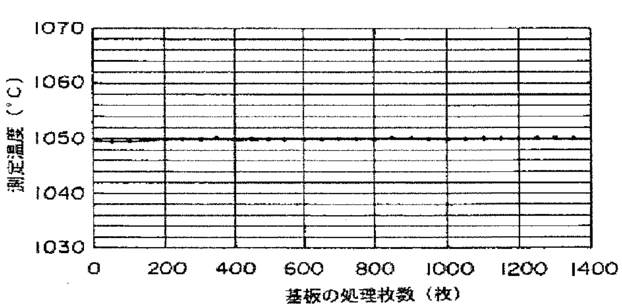

【図９】



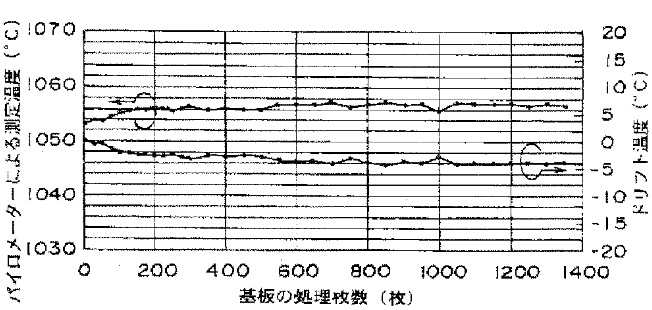

【図１０】



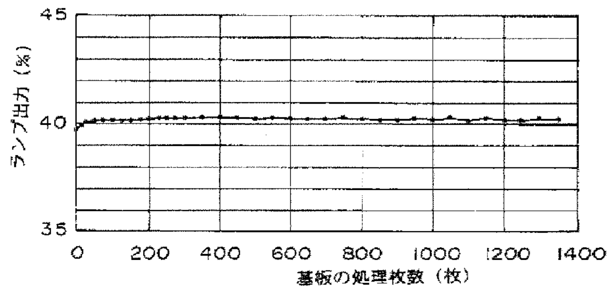

【図１１】




【図１２】



【図１３】



# PATENT ABSTRACTS OF JAPAN

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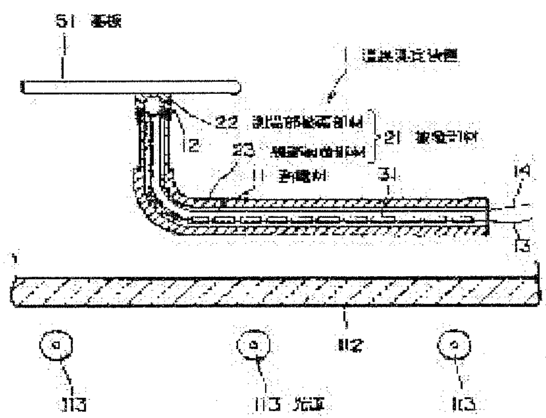
(71)Applicant : SONY CORP

(72)Inventor : YANAGAWA SHUSAKU

## (54) TEMPERATURE CONTROL METHOD FOR HEAT TREATMENT PROCESS IN PRODUCTION OF SEMICONDUCTOR DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To control the board temperature accurately even when a board having radiation rate or light absorption (treating temperature) dependent on the film structure, film quality, impurity concentration, or the like, is heat treated by feeding the board temperature back to the lamp output and using it in closed circuit control for controlling the board to a desired temperature.




SOLUTION: Temperature control method for measuring the temperature of a board 51 being heated through irradiation with light from a light source 113 by means of a thermocouple 11 without touching the board using a temperature measuring unit 1 contained in a heating furnace having the light source 113 as a heating means comprises a step for measuring the temperature of the board 51 using the temperature measuring unit 1 which is made of a high thermal conductivity material on the periphery of the contact part with the board 51 (temperature measuring part coating member 22) in the coating member 21 of the thermocouple 12 thereof and the coating member 21 (line part coating member 23) is made of a material having high light transmittance or reflectance except the periphery of the contact part, a step for measuring the temperature of the board 51 using the temperature measuring unit 1, and a step performing closed circuit control for feeding a measured value back to the output of the light source 113.

## LEGAL STATUS

| | |
|---|---|
| [Date of request for examination] | 12.12.2003 |
| [Date of sending the examiner's decision of rejection] | |
| [Kind of final disposal of application other than the examiner's decision of rejection or application converted registration] | withdrawal |
| [Date of final disposal for application] | 17.03.2006 |

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

## CLAIMS

[Claim(s)]
[Claim 1] It is the temperature control approach in the heat treatment process of the semiconductor device manufacture using the thermometry equipment which measures with a thermocouple the temperature of the substrate which is held in the heating furnace which has the light source for a heating means, and is heated by the optical exposure from said light source to a contact process. The contact section circumference with said substrate in the covering member which covers the thermocouple of said thermometry equipment is formed with an ingredient with high thermal conductivity. And the process which measures the temperature of said substrate using this thermometry equipment in which said covering member except the contact section circumference with said substrate was formed with the ingredient with high light transmittance, or the high ingredient of the reflection factor of light, The temperature control approach in the heat treatment process of the semiconductor device manufacture characterized by having fed back said measured value to the output of said light source, and having the process which performs the closed loop control which adjusts the output of this light source so that the temperature of said substrate may be held to predetermined within the limits.
[Claim 2] The temperature control approach in the heat treatment process of the semiconductor device manufacture characterized by measuring the temperature of said substrate using said thermometry equipment with which the covering member of the contact section circumference with said substrate consists of carbonization silicon, a silicon compound, or an alumina in the temperature control approach in the heat treatment process of semiconductor device manufacture according to claim 1.
[Claim 3] It is the temperature control approach in the heat treatment process of the semiconductor device manufacture characterized by using for the thermometry of said substrate after said thermometry equipment heat-treats the count of predetermined in the temperature control approach in the heat treatment process of semiconductor device manufacture according to claim 1.
[Claim 4] It is the temperature control approach in the heat treatment process of the semiconductor device manufacture characterized by using for the thermometry of said substrate after said thermometry equipment heat-treats the count of predetermined in the temperature control approach in the heat treatment process of semiconductor device manufacture according to claim 1.

[Translation done.]

## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the temperature control approach by the closed loop control in detail about the temperature control approach in the heat treatment process of semiconductor device manufacture.
[0002]
[Description of the Prior Art] In order to control ** short channel effect with an MOS device with detailed-izing of a semiconductor device in recent years, with ** bipolar device, it is cut-off frequency fT. In order to make it improve, the need of forming shallow junction with high precision has arisen. And as one of the approaches of forming shallow junction, the heating approach (RTA:Rapid Thermal Annealing) by the optical exposure which can process short-time is adopted at the elevated temperature. Moreover, RTA is used also for formation of various annealing, such as recovery of the crystal defect produced by the ion implantation, and a sinter, an oxide film, and a nitride. Therefore, it is very important to control substrate temperature correctly to the substrate which has various membrane structures, the substrate which has various high impurity concentration.
[0003] However, since the emissivity of a substrate changes with membrane structure, membraneous qualities, high impurity concentration, etc. in substrate heating by optical exposure, the exposure reinforcement of light will change [ the amount of light absorption of a substrate (processing temperature) ] under regularity [an open loop control (Open Loop Control)]. Therefore, it is very difficult to control the heating condition of a substrate including various dispersion (dispersion by thickness, membraneous quality, the amount of impurities, structure, etc.) with a sufficient precision with complication of a production process. The processing temperature of a substrate changes with change of the light transmittance of the quartz tube which furthermore constitutes substrate heating apparatus, the rate of a light reflex of the wall of a chamber, and the output of the lamp used as the light source with time etc. In order to cope with this problem, the closed loop control (Closed Loop Control) which measures the temperature of a substrate and feeds back that measured value to the output of a lamp is examined. If measurement of substrate temperature with a high precision is realizable by this, the outstanding substrate temperature control will become possible.
[0004] Moreover, there is a radiation thermometer as equipment which measures the temperature of a substrate. This radiation thermometer has the advantage whose thermometry is possible in non-contact. There is a thermocouple as another thermometry equipment. In carrying out a thermometry with a thermocouple, there are an approach of contacting a thermocouple directly on the surface of a substrate, the approach of fixing a thermocouple on the surface of a substrate using heat-resistant adhesives, etc. Since the temperature measurement section (alloy section) of a thermocouple contacts a substrate directly, these approaches have the advantage in which substrate temperature can be measured almost correctly.
[0005] A thermocouple is interpolated in the covering member which consists of silicon carbide (SiC) as other thermometry equipments, the thermocouple is contacted to a substrate through a covering member, and the equipment which measures substrate temperature indirectly is

indicated by JP,4-148546,A.
[0006]
[Problem(s) to be Solved by the Invention] However, in the thermometry using the above-mentioned radiation thermometer, unlike the thermometry approach of the contact process which used the thermocouple, the accuracy of measurement is influenced by the surface state of the measuring object, or it is strongly influenced of a measurement environment. Therefore, it is difficult for emissivity to differ for every substrate in a substrate with various membrane structures and high impurity concentration, and to perform an exact thermometry.
[0007] Moreover, by the approach of contacting a thermocouple to a substrate directly and carrying out a thermometry to it, problems, such as degradation of the thermocouple by the reaction of a substrate and a thermocouple and metal contamination of a substrate, occur.
[0008] In the thermometry by the thermocouple which furthermore carried out interior to the covering member, although the problem of the metal contamination to the substrate by the thermocouple is solved, it becomes the temperature of a covering member that the thermocouple has measured. Moreover, in the process in which a substrate is heat-treated by the optical exposure mold thermal treatment equipment, if the temperature of a substrate rises, it will absorb directly the light by which the covering member itself was irradiated, and a covering member is not only heated by heat conduction, but will be heated. Therefore, since the amount of heating by the light absorption of a covering member changes depending on exposure reinforcement, the closed loop control which changes optical exposure reinforcement is difficult for measuring correctly change of the amount of light absorption by change of the emissivity of a substrate with various membrane structures and high impurity concentration (substrate temperature). Thus, there was a problem in the substrate temperature control by the conventional closed loop control from there being no high measurement technique of the precision of substrate temperature.
[0009] Moreover, the radiation absorption from heat conduction and the covering member from a substrate and absorption of an exposure lamp light change with ingredients used as a covering member. When the case of a quartz and carbonization silicon (SiC) is shown in an example, although light absorption is suppressed, since heat conduction is bad, by covering by the quartz, heat responsibility is also difficultly inferior in measurement of substrate temperature. On the other hand, in covering by carbonization silicon, although excelled in conduction of substrate temperature, since there is much light absorption, optical exposure dependence of measurement temperature on the strength appears notably. There are merits and demerits in each ingredient with such a heat characteristic.
[0010] Moreover, in the contact section of a covering member and a substrate, a covering member is processed evenly, and a false field contact condition is formed, and there is the approach of increasing the heat-conduction effectiveness from a substrate, and it also becomes increasing the heat capacity of a covering member by this approach. Therefore, since heating by direct absorption of light increases, the thermometry of an exact substrate cannot be performed.

[0011] Therefore, in the closed loop control which changes optical exposure reinforcement, since the amount of heating by the light absorption of a covering member changes depending on exposure reinforcement, change of the amount of light absorption by change of the emissivity of a substrate with various membrane structures or high impurity concentration (substrate temperature) cannot be measured correctly.
[0012]
[Means for Solving the Problem] This invention is the temperature control approach in the heat treatment process of the semiconductor device manufacture made in order to solve the above-mentioned technical problem, and is the temperature control approach using the thermometry equipment which measures with a thermocouple the temperature of the substrate which is held in the heating furnace which has the light source for a heating means, and is heated by the optical exposure from the light source to a contact process. The contact section circumference with the substrate in the covering member which covers the thermocouple of the above-mentioned thermometry equipment is formed with an ingredient with high thermal conductivity.

And the process which measures the temperature of a substrate using such thermometry equipment in which the covering member except the contact section circumference with a substrate is formed with the ingredient with high light transmittance, or the ingredient with the high reflection factor of light, It has the process which performs the closed loop control which feeds back the measured value to the output of said light source.

[0013] By the temperature control approach in the heat treatment process of the above-mentioned semiconductor device manufacture, the control precision of substrate temperature increases by combining measurement of the substrate temperature by the thermometry equipment of the above-mentioned configuration, and the closed loop control which feeds back the measured value to the output of the light source. That is, a thermocouple is covered with a covering member, and among this covering member, since the covering member of a wrap part consists of a thermally conductive high ingredient, the heat of a substrate becomes easy to conduct the temperature measurement section in the temperature measurement section with the above-mentioned thermometry equipment. Therefore, although it is a thermometry through a covering member, it becomes possible to measure the temperature of a substrate with a sufficient precision.

[0014] Moreover, since the covering member of other parts except the covering member which consists of a high ingredient of this thermal conductivity consists of an ingredient with the high permeability of light, or an ingredient with the high reflection factor of light, it does not almost have that the covering member of that part absorbs that light in response to the exposure of light. Therefore, since the temperature rise of the covering member by the exposure of light is almost lost, the temperature measurement value change of the thermocouple by endoergic [ of a covering member ] and the temperature measurement value change by the radiation from a substrate hardly happen. Therefore, since it becomes possible to measure substrate temperature with high precision and it applies feedback to the output of the light source based on the temperature, it becomes possible to control substrate temperature with high precision.

[0015]

[Embodiment of the Invention] An outline sectional view explains thermometry equipment for an example of the operation gestalt of the temperature control approach in the heat treatment process of the semiconductor device manufacture concerning this invention to drawing 1 with a substrate, and the outline configuration sectional view of drawing 2 explains an example of an optical exposure mold thermal treatment equipment.

[0016] As shown in drawing 1 , the thermometry equipment 1 used for the thermometry of a heat-treated substrate in the heat treatment process of semiconductor device manufacture is held in the heating furnace (tube 112 made from a quartz) which has the light source 113 for a heating means to explain by drawing 2 , and measures the temperature of the substrate 51 heated by the optical exposure from the above-mentioned light source 113 to a contact process with a thermocouple 11. The contact section circumference (temperature measurement section covering member 22 of the temperature measurement section 12) with the above-mentioned substrate 51 in the covering member 21 which covers the thermocouple 11 consists of an ingredient with high thermal conductivity. As such an ingredient, carbonization silicon, the silicon compound (for example, silicide, such as molybdenum silicide, titanium silicide, and cobalt silicide), or the alumina is used, for example. On the other hand, the covering member 21 (line part covering member 23) of the above-mentioned thermometry equipment 1 except the contact section circumference with the above-mentioned substrate 51 consists of an ingredient with high light transmittance, or an ingredient with the high reflection factor of light. As an ingredient with high light transmittance, the quartz is used, for example. Or as an ingredient with the high reflection factor of light, the alumina is used, for example.

[0017] Specifically, the thermometry equipment 1 which consists of a contact process thermocouple has the structure where the thermocouple 11 is covered with the covering member 21. This thermocouple 11 is for example, platinum (Pt)-platinum (Pt) and 10% rhodium (Rh) thermocouple, and the temperature measurement section (alloy section) 12 of a thermocouple 11 is formed with the alloy of a platinum wire, and a platinum and 10% rhodium line. Moreover, at least, one of lines is inserted in the insulating tube 31, and this insulating tube 31

consists of a quartz. In this example, the direction of the lead wire 13 of platinum is inserted in the insulating tube 31. With the natural thing, the direction of platinum and 10% rhodium line 14 may be inserted in the insulating tube 31.
[0018] Among the above-mentioned covering members 21, the temperature measurement section covering member 22 of a wrap part consists of thermally conductive high ingredients, and the above-mentioned temperature measurement section 12 is formed in the condition of fully contacting the temperature measurement section 12. This temperature measurement section covering member 22 consists of an ingredient which has the thermal conductivity more than decade extent of a quartz (thermal conductivity = 1.66 W-m -1-K-1), and an ingredient which has thermal conductivity with a 100 W-m of -1-K-1 or more about preferably. As such an ingredient, there is carbonization silicon (thermal conductivity = 261 W-m -1-K-1), for example.
[0019] The above-mentioned temperature measurement section covering member 22 fully contacts the temperature measurement section 12, and is formed with the carbonization silicon which is a thermally conductive high ingredient. Although it is the thermometry which minds the temperature measurement section covering member 22 from this, it enables the heat of a substrate 51 to fully measure the temperature of propagation and a substrate 51 to the temperature measurement section 12. Furthermore, the temperature measurement section covering member 22 is small in surface area, in order to suppress direct absorption of light as much as possible, and in order to raise heat responsibility, it is made into the structure where heat capacity is small. That is, the configuration of the temperature measurement section covering member 22 has constituted the cap configuration to the temperature measurement section 12, for example, the bore of 1.4mm and a cap is formed in height of 1.4mm of 0.9mm and a cap for the outer diameter of a cap.
[0020] Moreover, among the above-mentioned covering members 21, the line part covering member 23 of other parts except the above-mentioned temperature measurement section covering member 22 consists of quartzes excellent in infrared permeability, and since it is formed in the shape of [ which has a circular cross section as structure which moreover suppressed direct absorption of light as much as possible ] tubing, even if it receives the exposure of light, it does not almost have absorbing the light. Therefore, since the temperature rise of the line part covering member 23 by the exposure of light is almost lost, the temperature measurement value change of the thermocouple 11 by endoergic [ of the line part covering member 23 ] hardly happens.
[0021] Moreover, generally each front face of the lead wire 13 and 14 of a thermocouple 11 is formed in the condition of being easy to reflect light. Therefore, even if light is irradiated by the thermocouple 11, a thermocouple 11 is hardly influenced of the irradiated light. Furthermore, since the above-mentioned temperature measurement section covering member 22 is thermally formed with stable carbonization silicon with the heat treatment temperature (1200 degrees C or less) of the usual silicon substrate with high thermal resistance, a substrate 51 is not polluted by the above-mentioned temperature measurement section covering member 22 at the time of heat treatment.
[0022] In addition, the substrate 51 is horizontally supported by the temperature measurement section covering member 22 which becomes a part for the point of the above-mentioned thermometry equipment 1 with two or more substrate supporters (2 [ for example, ]) made from a quartz (illustration abbreviation) projected from the quartz tray (illustration abbreviation).
[0023] Next, the outline configuration sectional view of drawing 2 explains an example of the optical exposure mold thermal treatment equipment which uses the thermometry equipment 1 explained with the above-mentioned operation gestalt.
[0024] As shown in drawing 2 , the tube 112 which becomes with the quartz glass which has high permeability to infrared radiation is installed in the interior of the fission reactor 111 covered with gold, and the halogen lamp which serves as the light source 113 for heating at the side periphery of this tube 112 is installed in it. And it opens and closes in the case of the taking-out close of a substrate 51, and the end side of the above-mentioned tube 112 is prepared in the end side of a fission reactor 111, and when sealing the inside of the above-mentioned tube 112 further, that part is equipped with the door 115 equipped with packing 114 (for example, packing

made of resin) so that the inside of this tube 112 can be made airtight.
[0025] On the other hand, the gas installation tubing 116 for introducing gas is connected to the other end side of the above-mentioned tube 112. And the tray 117 made from the quartz for supporting a substrate 51 is put on the interior of the above-mentioned tube 112. The substrate supporter 118 made from a quartz is formed in this tray 117, and the substrate 51 is supported by the point (temperature measurement section 12 through the temperature measurement section covering member 22 explained by said drawing 1 ) of the thermometry equipment 1 arranged on a tray 117 with this substrate supporter 118. Moreover, the lead wire 13 and 14 of the thermocouple of thermometry equipment 1 is pulled out outside from the hole 119 prepared in the edge of a fission reactor 111. Moreover, the aperture 120 which makes a thermometry possible by the pyrometer 131 is formed in the fission reactor 111. Thus, the optical exposure mold thermal treatment equipment 101 is constituted.
[0026] At the 1st process, the temperature of the above-mentioned substrate 51 heated by the optical exposure mold thermal treatment equipment 101 explained by drawing 2 is measured using the thermometry equipment 1 explained by above-mentioned drawing 1 .
[0027] Subsequently, at the 2nd process, the measured value of the temperature of the above-mentioned substrate 51 is fed back to the output of the above-mentioned light source 113, and the closed loop control which adjusts the output of the light source 113 so that the temperature of a substrate 51 may be held to predetermined within the limits is performed.
[0028] When the above-mentioned closed loop control has for example, high substrate temperature, the difference of the measurement temperature value and laying temperature value is searched for. Based on the difference, decrease the output of the light source 113, and it is made to make substrate temperature in agreement with laying temperature. On the other hand, when substrate temperature is low, the difference of the measurement temperature value and laying temperature value is searched for, and by making the output of the light source 113 increase based on the difference, as substrate temperature is made in agreement with laying temperature, substrate temperature is always held at laying temperature. What is necessary is just to determine the amount of increase and decrease of the output of the light source based on the data for which it asked beforehand, for example from the difference of the measured value of the above-mentioned substrate temperature, and a laying temperature value.
[0029] By the temperature control approach in the heat treatment process of the above-mentioned semiconductor device manufacture, the precision of the temperature control of a substrate 51 increases by combining the thermometry of the substrate 51 by the thermometry equipment 1 of the above-mentioned configuration, and the closed loop control which feeds back the measured value to the output of the light source 113. That is, a thermocouple 11 is covered with the covering member 21, and among this covering member 21, since the temperature measurement section covering member 22 of a wrap part consists of a thermally conductive high ingredient, the temperature of a substrate 51 becomes easy to conduct the temperature measurement section 12 in the temperature measurement section 12 with the above-mentioned thermometry equipment 1. Therefore, although it is a thermometry through the temperature measurement section covering member 22, it becomes possible to measure the temperature of a substrate 51 with a sufficient precision.
[0030] Moreover, since the line part covering member 23 of other parts except the temperature measurement section covering member 22 consists of an ingredient with the high permeability of light, or an ingredient with the high reflection factor of light, it does not almost have that the line part covering member 23 absorbs the light in response to the exposure of light. Therefore, since the temperature rise of the line part covering member 23 by the exposure of light is almost lost, the temperature measurement value change of the thermocouple 11 by endoergic [ of the line part covering member 23 ] and the temperature measurement value change by the radiation from a substrate 51 hardly happen. Therefore, since it becomes possible to measure the temperature of a substrate 51 with high precision and it applies feedback to the output of the light source 113 based on the temperature, it becomes possible to control the temperature of a substrate 51 with high precision.
[0031] Next, the outline configuration sectional view of drawing 3 explains the thermometry

equipment of the conventional contact process thermocouple as an example of a comparison. In drawing 3 , the thermometry equipment 201 of a conventional type is inserted into the tube 112 made from the quartz of an optical exposure mold thermal treatment equipment, the condition of having measured the temperature of a substrate 51 is shown, and the same sign is given to the same thing as the component part explained by said drawing 1 . The thermometry equipment 201 of this conventional type has structure covered with the covering member 221 which a thermocouple 11 becomes from carbonization silicon (SiC). This thermocouple 11 is for example, platinum (Pt)-platinum (Pt) and 10% rhodium (Rh) thermocouple, and the temperature measurement section (alloy section) 12 of a thermocouple 11 is formed with the alloy of a platinum wire, and a platinum and 10% rhodium line. Moreover, at least, one of lines is inserted in the insulating tube 31, and this insulating tube 31 consists of a quartz. In this example, the direction of the lead wire 13 of platinum is inserted in the insulating tube 31.

[0032] With the thermometry equipment 201 of the above-mentioned conventional type, it is the temperature of the covering member 221 which the thermocouple 11 has measured. If a substrate 51 is heated and the temperature rises in the process in which a substrate 51 is heat-treated by the optical exposure mold thermal treatment equipment (illustration abbreviation), since covering member 221 self will absorb the light of the light source 113 directly and it the covering member 221 is not only heated by heat conduction from a substrate 51, but will be heated, exact measurement of substrate temperature becomes difficult. When it changes with ingredients used as a covering member 221 and the case of a quartz and carbonization silicon is shown in an example, since [ with little radiation absorption ] heat conduction of a quartz is bad, as for the radiation from the substrate 51 of heat conduction from a substrate 51, and the covering member 221, and the absorption of light from the light source 113, measurement of substrate temperature is difficultly inferior [ a quartz ] also in heat responsibility. On the other hand, in covering by carbonization silicon, since carbonization silicon has much radiation absorption and its heat conduction is good, although excelled in conduction of substrate temperature, there is much light absorption and optical exposure dependence of measurement temperature on the strength appears notably.

[0033] Next, drawing 4 explains the structure of three kinds of samples to which the thickness for changing the emissivity of a substrate was changed.

[0034] As shown in (1) of drawing 4 , the laminating of the capping oxidation silicone film 65 of the thickness of 64,300nm of polycrystal silicone films of the thickness of 63,150nm of silicon oxide ($SiO_2$) film is carried out to the one side (front-face side) of a silicon substrate 62, and, as for the 1st evaluation sample 61, the laminating of the polycrystal silicone film 67 of the thickness of 66,150nm of silicon oxide ($SiO_2$) film is carried out to the other side (rear-face side) of a silicon substrate 62. And although the above-mentioned oxidation silicone films 63 and 66 are changing thickness in 700nm - 900nm, the thickness dependencies of the amount of light absorption are few things. Moreover, the ion implantation of the 2 boron fluoride ($BF_2$) is carried out on the conditions which it is devoted to the polycrystal silicone film 64, and 40keV(s) and a dose become [ energy ] 5.4x1014-piece [/cm ] 2.

[0035] As shown in (2) of drawing 4 , the laminating of the capping oxidation silicone film 75 of the thickness of 74,300nm of polycrystal silicone films of the thickness of 73,150nm of silicon oxide ($SiO_2$) film with a thickness of 800nm is carried out to the one side (front-face side) of a silicon substrate 72, and, as for the 2nd evaluation sample 71, the laminating of the silicon oxide ($SiO_2$) film 76 with a thickness of 800nm and the polycrystal silicone film 77 is carried out to the other side (rear-face side) of a silicon substrate 72. And the polycrystal silicone film 77 by the side of the above-mentioned rear face is changing thickness in 150nm - 350nm, and the thickness dependency of the amount of light absorption is large rather than the 1st evaluation sample 61. Moreover, in the polycrystal silicone film 74 by the side of a front face, placing energy is 40keV(s) and a dose is 2 5.4x1014 pieces/cm. The ion implantation of the 2 boron fluoride ($BF_2$) is carried out on conditions.

[0036] As shown in (3) of drawing 4 , the laminating of the capping oxidation silicone film 85 of the thickness of 84,300nm of polycrystal silicone films of the thickness of 83,150nm of silicon oxide ($SiO_2$) film is carried out to the one side (front-face side) of a silicon substrate 82, and, as

for the 3rd evaluation sample 81, the laminating of the polycrystal silicone film 87 of the thickness of 86,150nm of silicon oxide (SiO2) film is carried out to the other side (rear-face side) of a silicon substrate 82. And as for the above-mentioned 3rd evaluation sample 81, that whose thickness of the oxidation silicone films 83 and 86 is five kinds which are the range which is 100nm - 600nm, i.e., 100nm, 200nm, 300nm, 400nm, and 600nm is prepared. Therefore, in these 3rd evaluation samples 81, the thickness dependency of the light absorption of the oxidation silicone films 83 and 86 is very large. Moreover, in the polycrystal silicone film 84, placing energy is 40keV(s) and a dose is 2 5.4x1014 pieces/cm. The ion implantation of the 2 boron fluoride (BF2) is carried out on conditions.

[0037] two or more every from which the thickness of the oxidation silicone film 63 differs -- two or more every from which the thickness of the 1st evaluation sample 61 and the polycrystal silicone film 77 differs -- two or more every from which the thickness of the 2nd evaluation sample 71 and the oxidation silicone films 83 and 86 differs -- the 3rd evaluation sample 81 was alike, respectively, the thermocouple was directly stuck using heat-resistant adhesives, and the exact thermometry using the thermocouple was performed.

[0038] In the thermometry, each 1st, 2nd, and 3rd evaluation samples 61, 71, and 81 explained by above-mentioned drawing 4 instead of the substrate 51 using the optical exposure mold thermal treatment equipment 101 explained by said drawing 2 were heat-treated [RTA (Rapid Thermal Annealing)]. The sequence of RTA carries in an evaluation sample in the tube 112 (refer to drawing 2 ) set as the 200-degree C temperature ambient atmosphere, as shown in drawing 5 . And after heating to the laying temperature T of RTA with the heating rate of 50 degrees C/s, it is the order of carrying out maintenance for t seconds (for example, for 10 seconds) at the laying temperature T, cooling to 400 degrees C with the cooling rate of 50 degrees C/s after that, and taking out an evaluation sample from the inside of a tube 112. The laying temperature T of Above RTA was set as 900 degrees C, 1000 degrees C, 1050 degrees C, 1100 degrees C, and 1150 degrees C. In addition, the sequence of Above RTA is an example and changing suitably is possible.

[0039] Here, the temperature dependence of the sheet resistance of each evaluation sample when processing with each laying temperature is shown in drawing 6 . By drawing 6 , sheet resistance rhos is shown on an axis of ordinate, and the laying temperature of RTA is shown on an axis of abscissa by it. If 900 to about 950 degrees C show the sheet resistance of almost fixed 2140ohms / ** extent and becomes an elevated temperature from about 1000 degrees C as shown in drawing 6 , sheet resistance will fall rapidly. And at 1050 degrees C, it became the sheet resistance of 1420ohms / ** extent, and 1100 degrees C showed the sheet resistance of 980ohms / ** extent, and it became the sheet resistance of 800ohms / ** extent at 1150 degrees C.

[0040] Drawing 7 shows the relation of the sheet resistance rhos (axis of ordinate) of each evaluation sample and measurement temperature (axis of abscissa) which were measured with the thermometry machine 1 (refer to drawing 1 ) of this invention, and the thermometry equipment 201 (refer to drawing 3 ) of a conventional type. The round head of void, a trigonum, and the square mark show the measured value with the thermometry machine 1, and a black-lacquered round head, a trigonum, and the square mark show the measured value by thermometry equipment 201.

[0041] In the evaluation sample whose thickness of the polycrystal silicone film 77 in the 2nd evaluation sample 71 is 250nm, substrate temperature specifically uses a lamp output which becomes 1050 degrees C. It heat-treats with the same lamp output to all the evaluation samples that changed the thickness of the oxidation silicone films 63 and 66 of the 1st evaluation sample 61, the thickness of the polycrystal silicone film 77 of the 2nd evaluation sample 71, and the thickness of the oxidation silicone films 83 and 86 of the 3rd evaluation sample 81. That is, the exposure reinforcement of light performs consecutive processing by the open loop control of heat-treating by the fixed basis, and measures sheet resistance and substrate temperature.

[0042] As shown in drawing 7 , sheet resistance (substrate temperature) changes with the differences in the thickness of the film formed in the substrate front face in the open loop control which does not depend on a substrate but is processed by the same optical exposure

reinforcement. Moreover, in drawing 6 and drawing 7 , if the curve of temperature dependence of the sheet resistance by the laying temperature of RTA is compared with the curve of temperature dependence of the sheet resistance in the measurement temperature by thermometry equipment 1, the curved form is in agreement. It is shown also to various substrates with which substrate structures differ and with which the amount of absorption of light is different from this that thermometry equipment 1 (refer to drawing 1 ) can improve [ exact measurement of substrate temperature ] repeatability. On the other hand, as for the relation between the measurement temperature measured with the thermometry equipment 201 (refer to drawing 3 ) of a conventional type, and the sheet resistance at that time, it turns out that it differs from the curve of temperature dependence of drawing 6 sharply, and it is shown that exact measurement of substrate temperature has not done the thermometry equipment 201 of a conventional type.

[0043] It processes at the measurement temperature of 1050 degrees C by the sequence which explained the sample to which the thickness of the oxidation silicone films 83 and 86 of the 3rd evaluation sample 81 was changed by said drawing 5 in the closed loop control using thermometry equipment 201 (refer to drawing 3 ) and thermometry equipment 1 (refer to drawing 1 ), and the thickness dependency of the sheet resistance at this time is shown in drawing 8 with the thickness dependency in an open loop control. By this drawing 8 , sheet resistance rhos is shown on an axis of ordinate, oxidation silicone film thickness is shown on an axis of abscissa by it, and the closed loop control according [ the square mark of an open loop control and void ] to thermometry equipment 1 in the black-lacquered round mark in drawing and the trigonum mark of void show the closed loop control by the thermometry equipment 201 of a conventional type by it. Moreover, similarly, the thickness dependency of the reduced temperature from sheet resistance is shown in drawing 9 , and the closed loop control according [ the square mark of an open loop control and void ] to thermometry equipment 1 in the black-lacquered round mark in drawing and the trigonum mark of void show the closed loop control by the thermometry equipment 201 of a conventional type. By this drawing 9 , substrate temperature is shown on an axis of ordinate, and oxidation silicone film thickness is shown on an axis of abscissa by it. Thickness dependence of the sheet resistance (substrate temperature) which appears notably in an open loop control improves by using thermometry equipment 1 so that clearly from drawing 8 and drawing 9 . However, with thermometry equipment 201, the improvement effect of thickness dependence of sheet resistance (substrate temperature) is not seen.

[0044] The lamp output at the time of the stability by the thickness of the oxidation silicone films 83 and 86 when processing at the measurement temperature of 1050 degrees C by the sequence which explained the sample to which the thickness of the oxidation silicone films 83 and 86 of the 3rd evaluation sample 81 was changed by the closed loop control using thermometry equipment 1 (refer to drawing 1 ) and thermometry equipment 201 (refer to drawing 3 ) by said drawing 5 was shown in drawing 10 . By this drawing 10 , a lamp output (power ratio to the maximum output) is shown on an axis of ordinate, oxidation silicone film thickness is shown on an axis of abscissa by it, and the closed loop control according [ the square mark of an open loop control and void ] to thermometry equipment 1 in the black-lacquered round mark in drawing and the trigonum mark of void show the closed loop control by the thermometry equipment 201 of a conventional type by it.

[0045] As shown in drawing 10 , in the closed loop control using thermometry equipment 1, it turns out that the higher lamp output was applied in the oxidation silicone film thickness to which substrate temperature becomes low, and substrate temperature is amended. However, with thermometry equipment 201, as shown in said drawing 7 , since measurement temperature hardly changes even if substrate temperature has actually changed, it does not depend on oxidation silicone film thickness, but becomes the almost same lamp output, and oxidation silicone film thickness has not amended substrate temperature. From the above thing, it is proving that thermometry equipment 201 is absorbing the light from a lamp directly with thermometry equipment 201. Thus, it turns out that it is necessary reduce the surface area of carbonization silicon and to make it the structure which suppressed light absorption as much as possible as structure of thermometry equipment. With the structure which covered the thermocouple 11

altogether like thermometry equipment 201 in short before, the light absorption of the measurement with a precision and sufficient in a closed loop control is impossible.
[0046] Although above-mentioned drawing 6 - drawing 10 showed the result of the closed loop control by thermometry equipment 1 using the result of the 3rd evaluation sample 81 which changes the amount of light absorption of a substrate extremely by oxidation silicone film thickness In the production process of the managed actual semiconductor device, there is little fluctuation of the light absorption (substrate temperature) by process dispersion of thickness or membraneous quality far, and thickness dependence of the sheet resistance (substrate temperature) in an open loop control can fully be canceled by the closed loop control using thermometry equipment 1.
[0047] As mentioned above, in order to perform accurate measurement in a closed loop control, it is necessary to make small structure of the carbonization silicon covered in the temperature measurement section as much as possible, and to suppress light absorption.
[0048] Although the effectiveness of a closed loop control was shown using the substrate into which thickness was changed and the amount of absorption of light was changed as an example In the closed loop control using thermometry equipment 1 (refer to drawing 1 ) In order to feed back to the output of the lamp which measures actual substrate temperature and serves as the light source 113, The light transmittance of the tube 112 made from a quartz and the rate of a light reflex of the wall of a fission reactor 111 which constitute the optical exposure mold thermal treatment equipment 101, Also when the processing temperature of the substrate 51 by change of the output of the lamp used as the light source 113 with time etc. changes, measurement of substrate temperature with a high precision is realized by this invention.
[0049] In order to evaluate the stability of this control approach, the closed loop control using thermometry equipment 1 (refer to drawing 1 ) estimated the stability of the closed loop control by the thermometry equipment 1 in consecutive processing of 1350 sheets by performing heat treatment for 10 seconds at the measurement temperature of 1050 degrees C by the sequence explained by said drawing 5 , and reading the output of the lamp used as the measurement temperature of the thermometry equipment 1 at this time, and a pyrometer, and the light source 113. The silicon substrate in which the 600nm thermal oxidation film (SiO2 film) was formed was used for the sample, and the measurement error of the pyrometer by emissivity dispersion of a silicon substrate was eliminated by performing the sampling of measurement temperature and a lamp output from the same silicon substrate.
[0050] Since transition of the measurement temperature of the thermometry equipment 1 shown in drawing 11 is a closed loop control by thermometry equipment 1, naturally it becomes fixed at 1050 degrees C. By this drawing 11 , measurement temperature is shown on an axis of ordinate, and the processing number of sheets of a substrate is shown on an axis of abscissa by it.
[0051] However, actual substrate temperature is not fixed because of the drift of thermometry equipment 1, and to the same sample, if this drift is the same conditions, it can be known by transition ( drawing 13 ) of the pyrometer which measures almost exact substrate temperature. Drawing 12 explains this result. This drawing 12 shows the measurement temperature by the pyrometer to a left-vertical shaft, and shows drift temperature to a right longitudinal shaft, and the processing number of sheets of a substrate is shown on an axis of abscissa by it. Since it begins to use new thermometry equipment 1 as shown in drawing 12 , although the about -3-degree C drift from 0 degree C is seen to about 200 sheets, it turns out after the 200th sheet that the temperature control **1.0 degrees C or less which was very excellent is possible focusing on -3 degrees C.
[0052] Moreover, the relation between a lamp output (axis of ordinate) and the processing number of sheets (axis of abscissa) of a substrate is shown in drawing 13 . The lamp output shown here is a ratio to the maximum lamp output. As shown in this drawing 13 , after a lamp output performs consecutive processing of about 50 sheets, it turns out that it becomes the output stabilized within the limits of about **0.5% of dispersion.
[0053] From the above thing, in case new thermometry equipment 1 is used, it is necessary to perform heat treatment for 10 seconds about 200 times at the measurement temperature of 1050 degrees C by the sequence explained, for example by said drawing 5 . Very stable substrate

temperature control is realized by the closed loop control by the thermometry equipment 1 which performed heat treatment which the count of predetermined followed. In addition, 200 times of the above-mentioned count of heat treatment are an example, and the count of heat treatment is suitably chosen by heat treatment conditions (temperature, time amount, etc.).

[0054]

[Effect of the Invention] As mentioned above, since according to this invention the covering member of the temperature measurement section of thermometry equipment consists of a thermally conductive high ingredient and substrate temperature fully becomes the temperature measurement section from an ingredient with propagation and the covering member of other parts high [ light transmittance or the rate of a light reflex ] as explained, the covering member of this part hardly absorbs light. Therefore, substrate temperature can be correctly measured with this thermometry equipment. Since it uses for the closed loop control which feeds back substrate temperature to a lamp output and controls this thermometry equipment to the temperature of a request of a substrate, even if it is the case where the substrate from which the emissivity and the amount of light absorption (processing temperature) by membrane structure, membraneous quality, high impurity concentration, etc. change is heat-treated, it becomes possible to control substrate temperature with a sufficient precision. Even if there is a change of the light transmittance of the quartz tube which furthermore constitutes an optical exposure mold thermal treatment equipment, the rate of a light reflex of a fission reactor wall, the output of the lamp used as the light source, etc. with time, stable control of substrate temperature is realizable.

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[Translation done.]

## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the explanatory view of the operation gestalt concerning the temperature control approach of this invention.
[Drawing 2] It is the outline configuration sectional view of the optical exposure mold thermal treatment equipment which uses thermometry equipment.
[Drawing 3] It is the outline configuration sectional view of the thermometry equipment of the example of a comparison.
[Drawing 4] It is the outline configuration sectional view of each evaluation sample.
[Drawing 5] It is the explanatory view of the sequence of RTA.
[Drawing 6] It is the related Fig. of the sheet resistance of each evaluation sample, and the laying temperature of RTA.
[Drawing 7] It is the related Fig. of the measurement temperature and sheet resistance by the thermometry equipment of this invention, and the thermometry equipment of the example of a comparison.
[Drawing 8] It is the related Fig. of the sheet resistance of the 3rd evaluation sample, and oxidation silicone film thickness.
[Drawing 9] It is the related Fig. of the substrate temperature of the 3rd evaluation sample, and oxidation silicone film thickness.
[Drawing 10] It is the related Fig. of the lamp power ratio in the 3rd evaluation sample, and oxidation silicone film thickness.
[Drawing 11] It is the related Fig. of the measurement temperature and the substrate processing number of sheets by the thermometry equipment of this invention in consecutive processing of RTA.
[Drawing 12] They are the related Fig. of the measurement temperature and the substrate processing number of sheets by the pyrometer in consecutive processing of RTA, and the related Fig. of the amount of drifts of the measurement temperature of the thermometry equipment of this invention, and substrate processing number of sheets.
[Drawing 13] It is the related Fig. of the lamp output and substrate processing number of sheets in consecutive processing of RTA.
[Description of Notations]
1 [ -- A temperature measurement section covering member, 23 / -- A line part covering member, 51 / -- A substrate, 113 / -- Light source ] -- Thermometry equipment, 11 -- A thermocouple, 21 -- A covering member, 22

[Translation done.]

* NOTICES *

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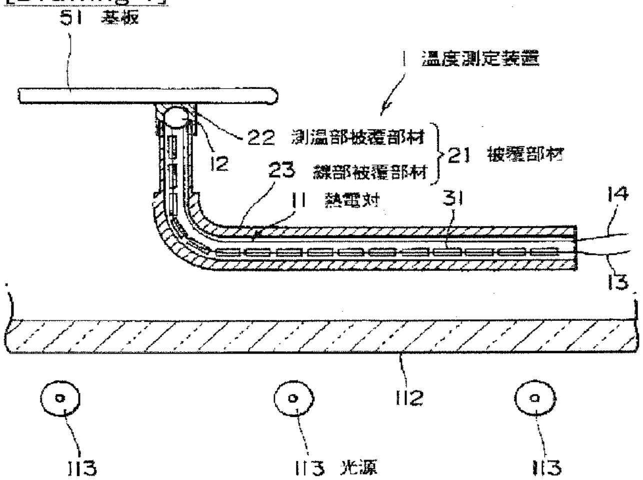
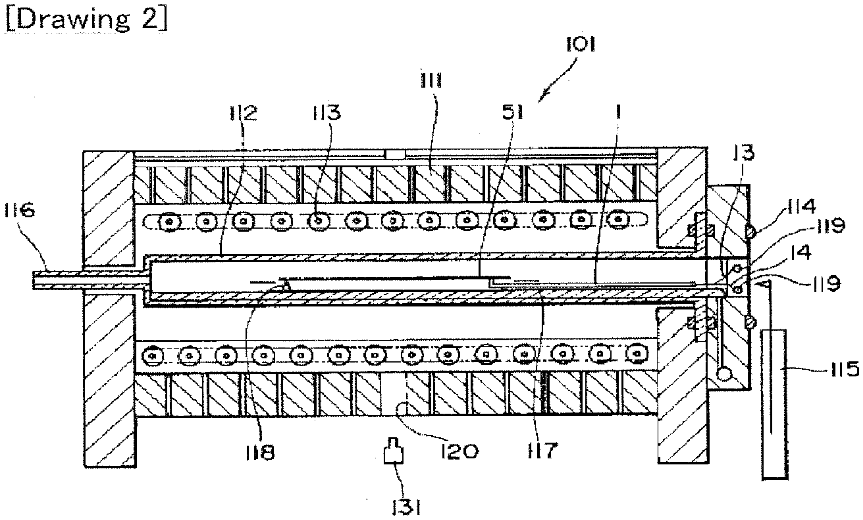
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

## DRAWINGS

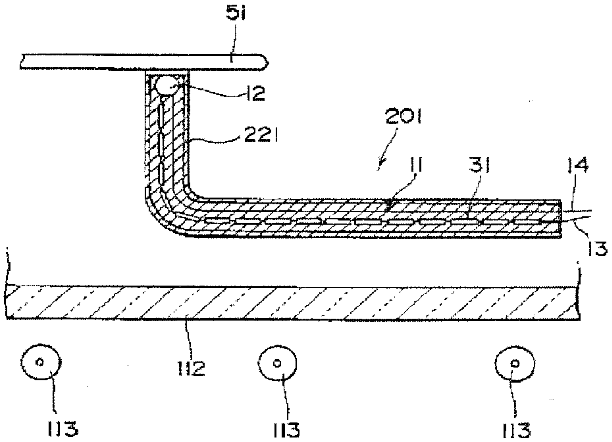
[Drawing 1]



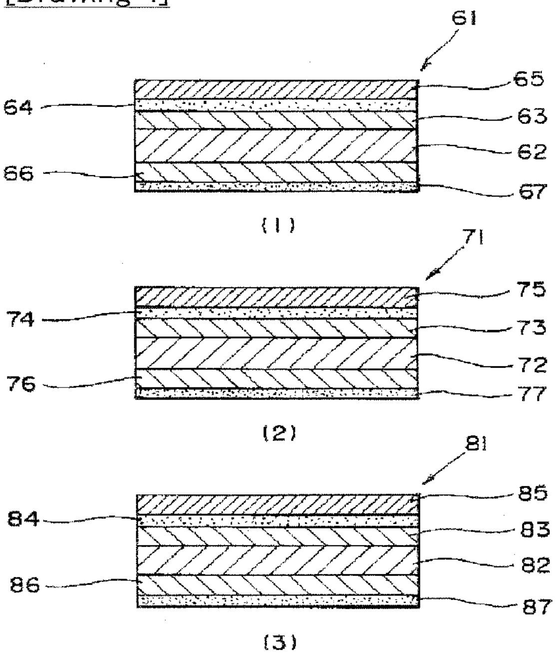

[Drawing 2]



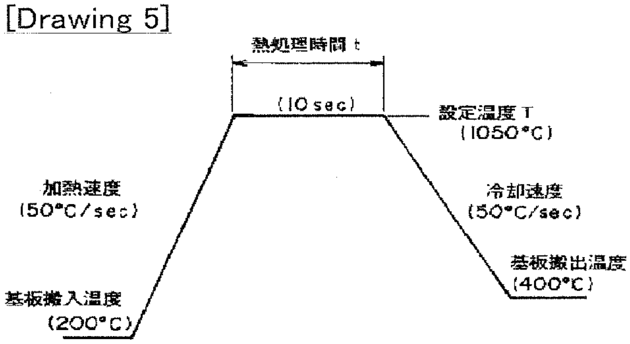

[Drawing 3]



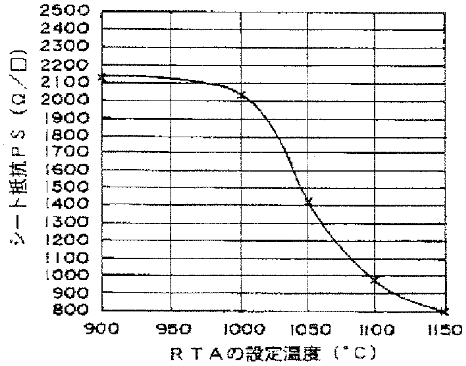

[Drawing 4]



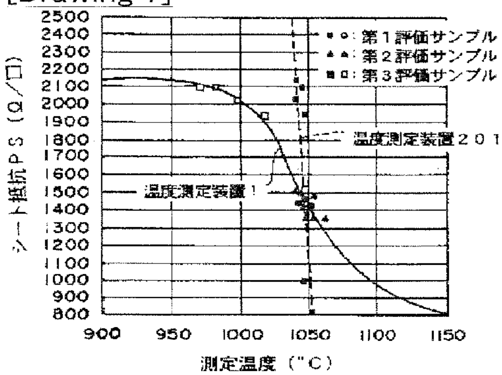

[Drawing 5]



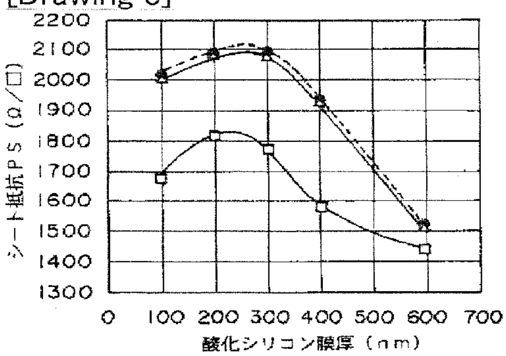

[Drawing 6]



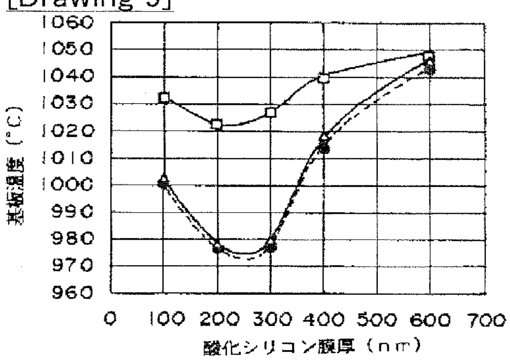

[Drawing 7]



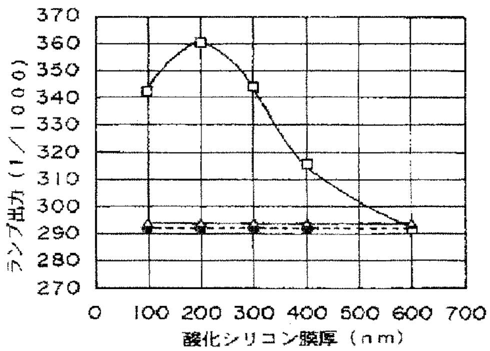

[Drawing 8]



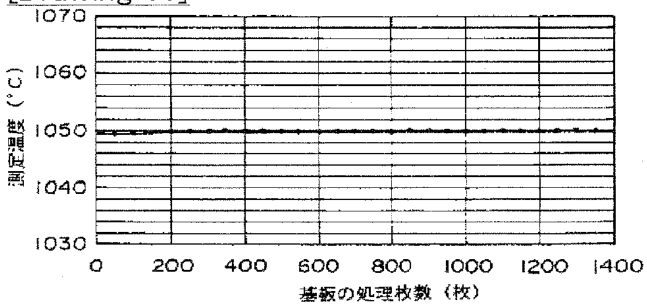

[Drawing 9]



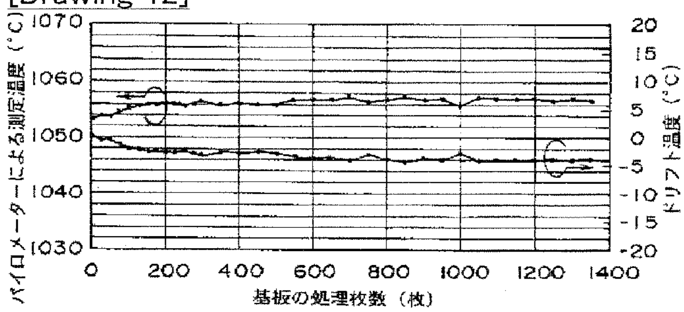

[Drawing 10]



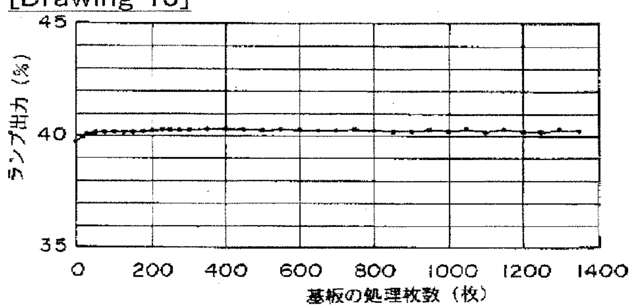

[Drawing 11]




[Drawing 12]




[Drawing 13]




[Translation done.]

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

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## CORRECTION OR AMENDMENT

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[Kind of official gazette] Printing of amendment by the convention of 2 of Article 17 of Patent Law
[Section partition] The 2nd partition of the 7th section
[Publication date] December 2, Heisei 16 (2004. 12.2)

[Publication No.] JP,11-163070,A
[Date of Publication] June 18, Heisei 11 (1999. 6.18)
[Application number] Japanese Patent Application No. 9-322643
[The 7th edition of International Patent Classification]

H01L 21/66
G01K 7/02
G05D 23/22
H01L 21/02

[FI]

| | |
|---|---|
| H01L 21/66 | T |
| G01K 7/02 | Z |
| G05D 23/22 | Z |
| H01L 21/02 | Z |

[Procedure revision]
[Filing Date] December 12, Heisei 15 (2003. 12.12)
[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] Claim 4
[Method of Amendment] Modification
[The contents of amendment]
[Claim 4]
In the temperature control approach in the heat treatment process of semiconductor device manufacture according to claim 2,
After said thermometry equipment heat-treats the count of predetermined, it is used for the thermometry of said substrate.
The temperature control approach in the heat treatment process of the semiconductor device manufacture characterized by things.

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[Translation done.]